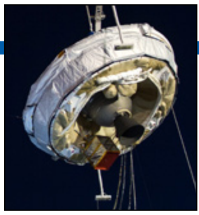
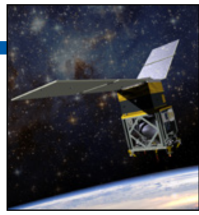
National Aeronautics and
Space Administration

Technology Demonstration Missions Program

The Bridge

Summer 2015






The Low Density Supersonic Decelerator test vehicle's onboard rocket motor is firing in this still captured from an in-flight video recording. The trailing parachute can be seen at the far right. (NASA)

NASA's LDSD Project Completes Second Experimental Test Flight

From a NASA news release

Engineers continue to pore over data obtained during the June 8 flight test of NASA's Low-Density Supersonic Decelerator project.

During the flight, the LDSD project team tested two decelerator technologies that could enable larger payloads to land safely on the surface of Mars, and allow access to more of the planet's surface by assisting landings at higher-altitude sites.

"Developing and demonstrating entry, descent and landing technologies such as supersonic decelerators is critical to enabling our journey to Mars," said Steve Jurczyk, associate administrator for the Space Technology Mission Directorate at NASA Headquarters. "The technologies tested on LDSD are giving us data and insight into the capabilities we'll need to land more mass than we currently can on Mars, which will enable more capable robotic missions, as well as human precursor missions to the Red Planet."

The directorate funds the project as part of NASA's Technology Demonstration Missions Program, which at the time of this writing anticipated analysis of the vehicle and flight data to continue for several months.

A high-altitude balloon carrying the saucer-shaped LDSD test vehicle launched the morning of the flight test from the U.S. Navy's Pacific Missile Range Facility on the Hawaiian island of Kauai. After nearly four hours of ascent, the vehicle separated as planned from the balloon about 120,000 feet above the ocean. An onboard rocket motor then took the vehicle to 180,000 feet, where the first braking technology, the Supersonic Inflatable Aerodynamic Decelerator, deployed at about Mach 3.

Fourteen seconds after SIAD inflation, the test vehicle's second braking technology — a 100-foot-wide Supersonic Ringsail parachute, the largest supersonic chute ever flown — was successfully released. Preliminary analysis of imagery and other data received during the test indicates the chute deployed, then began to generate large amounts of drag. A tear appeared in the canopy at about the time it was fully inflated.

The LDSD craft splashed down in the Pacific Ocean off the west coast of Kauai.

"Early indications are that we got what we came for: new and actionable data on our parachute design," said Mark Adler, LDSD project manager at NASA's Jet Propulsion Laboratory, during a post-flight news conference.

…continued on p. 2

Q&A: Meet TDM Program Manager Larry Gagliano

In April, Larry Gagliano was named manager of NASA's Technology Demonstration Missions program at NASA's Marshall Space Flight Center. "Bridge" editor Rick Smith recently sat down with him to discuss his NASA experience, his managerial style and his expectations for TDM.

A 1987 graduate of the University of Alabama in Tuscaloosa, Gagliano earned a bachelor's degree in aerospace engineering there. He also received a master's degree in technical management in 2000 from the Florida Institute of Technology in Huntsville. He joined NASA in 1988 as a mechanical engineer in Marshall's Propulsion Laboratory, and went on to train Spacelab astronauts and work on Hubble Space Telescope repair missions. For the bulk of his career, he supported the International

Space Station in a succession of payload engineering and management roles, including chief engineer for the space station's Microgravity Glovebox and program integration lead for the Node 2 and Node 3 elements, which became the station's "Harmony" and "Tranquility" modules, respectively.

…continued on p. 7

NASA's LDSD Project Completes Second Experimental Test Flight*...continued from p. 1*

The flight test was the second for the project. The first was held in June 2014 at the same Hawaiian test facility.

"The physics involved with LDSD are so cutting-edge we learn something profound every time we test," said Ian Clark, principal investigator for the project at JPL. "Going into this year's flight, I wanted to see that the parachute opened further than it did last year before it began to rupture. The limited data set we have at present indicates we may not only have gone well down the road to full inflation, but we may have achieved it."

Two members of the U.S. Navy's Mobile Diving Salvage Unit 1 Explosive Ordnance Detachment work to recover the LDSD test vehicle. (NASA)

Clark also noted the successful inflation of the SIAD and deployment and inflation of the supersonic ballute — an inflatable drag device that extracts the parachute. "Both of those devices have now had two great flights," he said, "and we have matured them to the point where they can be used, with confidence, on future missions.

"We're not just pushing the envelope," he added. "We flew a 7,000-pound test vehicle right through it."

For more about the teams involved in making the LDSD flight test happen, see the related story on page 2.

LDSD Flight Test Reflects Nationwide Teamwork

By Rick Smith

When NASA's Low-Density Supersonic Decelerator test vehicle flew high over the Pacific Ocean June 8 to test two innovative aerobraking technologies (see cover story), it did so thanks to the tenacity and ingenuity of workers at a host of NASA facilities, military installations and specialized companies that very nearly stretches from sea to shining sea.

The LDSD flight tested breakthrough technologies for landing future robotic and human missions on Mars and safely returning large payloads to Earth. Researchers lofted the test vehicle off the coast of Hawaii via a large NASA scientific balloon. A powerful rocket then boosted it to the edge of space before sending it hurtling toward the ocean below — simulating the supersonic speeds at which the craft would travel through Mars' atmosphere.

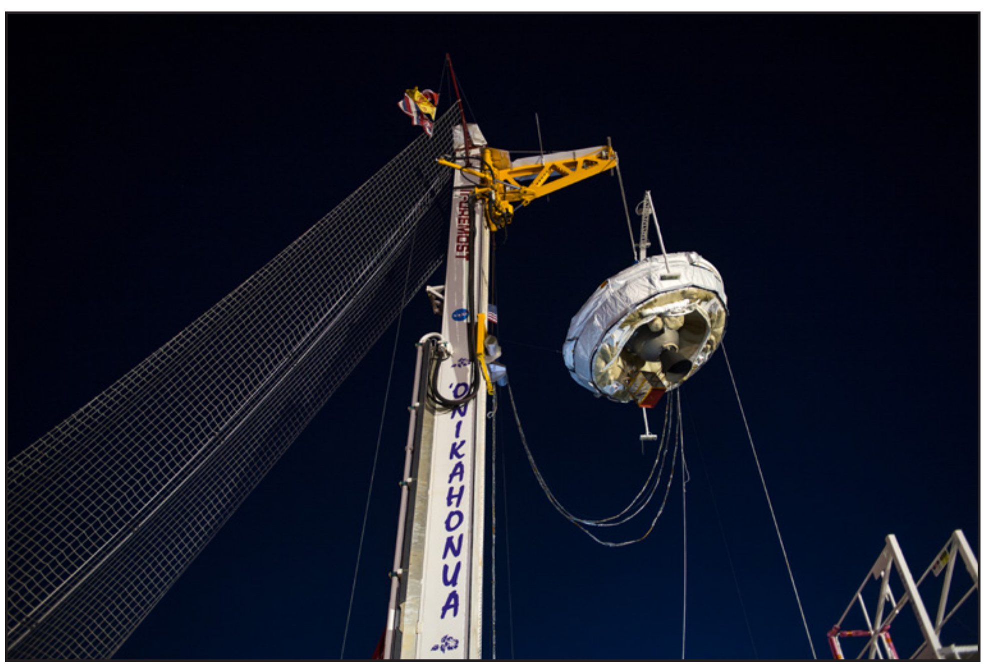
The flight test was a crucial milestone for proving two key technologies: a supersonic inflatable aerodynamic decelerator, or SIAD, a balloon-like vessel designed to inflate around a vehicle and slow its entry; and a state-of-the-art supersonic parachute. The groundbreaking nature of these technologies — and the unique challenges faced by the investigators seeking to test them in flight — is why NASA called upon such a widespread team for the job.

Partners nationwide — and beyond

The LDSD project is led by program manager Mark Adler and principal investigator Ian Clark at NASA's Jet Propulsion Laboratory. It is supported by NASA's Marshall Space Flight Center, which manages the project as part of the Technology Demonstration Missions program for NASA's Space Technology Mission Directorate.

NASA's Wallops Flight Facility, operated by NASA's Goddard Space Flight Center, is home to the agency's Balloon Program Office, which played a crucial role in preparing the balloon to lift the LDSD test vehicle into the stratosphere. Wallops also assisted with the launch, in tandem with the Columbia Scientific Balloon Facility, and with communications, range safety and recovery operations. JPL also turned to NASA's Ames Research Center, NASA's Langley Research Center and Marshall for wind tunnel testing, aerodynamics modeling and subscale testing, rocket plume thermal analysis and flight dynamics support prior to flight testing.

Wallops' balloon specialists helped guide design and delivery of the scientific balloon and oversaw the balloon launch. Wallops and Columbia personnel coordinated its flight with the U.S. Navy's Pacific Missile Range Facility, the designated launch site in Hawaii.



The test vehicle is suspended beneath the static launch tower during a May 29 rehearsal.
(Image: NASA/Bill Ingalls)

A number of commercial firms provided critical technologies and capabilities. The SIAD used in this test flight was built for NASA by ILC Dover, while the supersonic parachute — the largest ever constructed — was built by Zodiac Parachute & Protection America (formerly Pioneer Aerospace Corporation). A second SIAD and a backup parachute, the latter of which may be test-flown in 2016, were built by Airborne Systems.

On-site in Hawaii prior to launch, LDSD principal investigator Ian Clark, rear, watches as LDSD project manager Mark Adler discusses the flight test. Clark and Adler both work at NASA's Jet Propulsion Laboratory, which leads the LDSD project for the agency. (NASA/Bill Ingalls)

Orbital ATK designed, fabricated and tested the composite super-structure of the vehicle, while Orbital ATK's Defense Systems Group provided the STAR™ 48B motor. Orbital ATK's Technical Services Division, contracted to oversee the Columbia Scientific Balloon Facility, supplied the flight computer, inertial measurement unit and avionics. As a subcontractor to NASA's Atmospheric Technology Services Company, Orbital ATK also supplied 18 small sounding rockets for gathering meteorological data. The powerful "spin motors" necessary to rotate the test vehicle during its powered ascent were built by Nammo Talley. Canadian firm Foremost LLC built the special launch tower used to suspend the balloon while launch preparations were underway.

The Hawaii Resource Group, under contract to Wallops, provided recovery vessels — from among locally owned and operated fishing and commercial ships — to retrieve the test vehicle after splashdown. And in keeping with NASA's commitment to environmentally friendly practices, the Hawaiian firm Pacific Farm Services will recycle the spent balloon.

"We've done things nobody has ever done before," said Clark, reflecting on the roster of participants in the work. "We turned to every potential resource we could think of. It's crucial in cases like this to harness the talents, skills and knowledge base of experts across the agency and outside the agency. You look for expertise wherever it's available."

The path to flight

With a successful series of design studies, fabrication of test articles and ground tests behind the team, the search began for a way to launch the test vehicle to the proper altitude. The JPL leads considered various rocket-propelled solutions, but found them too costly.

"A scientific balloon turned out to be a relatively low-cost, efficient means of bringing our system much of the way to where it needed to be," Adler said. He credited Wallops' long experience with scientific balloons — and its close work with its contractors and with the Navy's Hawaii launch site — for bringing in the test flights on budget.

"From their technical expertise with balloons, range communication systems and recovery operations, to their direct knowledge of rocket range safety and logistics, I cannot imagine how we could have gotten where we are today without them," he said.

The project team conducted a worldwide search for its test site. They selected the Navy's PMRF range in 2011.

"It offered a fully supported range, a knowledgeable safety organization and a full contingent of experienced personnel," Adler said. "It also had the right conditions — a proper light sea breeze in the mornings near the surface, yet stiff winds higher up to send our balloon out over the sea. It was almost perfectly situated for our mission."

The Wallops team worked with the Navy facility to put in place special meteorology equipment and communications systems prior to the first LDSD flight test in 2014. The Columbia Scientific Balloon Facility, under contract to Wallops, "has decades of experience in building, launching and flying these enormous helium balloons," Adler said. "They also provided world-class meteorologists for weather forecasting, which was essential to knowing when it was both possible and safe to launch."

Reaping the rewards

How does Adler sum up the teamwork that helped reach this latest milestone? "When you start a project like this, you have no idea how many problems and complications you're going to run into," he said. "These partners all stepped up with their expertise, ingenuity and dedication to the mission to provide the solutions and support to make it a success."

"There's no way one organization could do even half the things we've done without seeking help and insight from others," Clark added. "That's what made LDSD fly."

The LDSD project is one of a series of Technology Demonstration Missions in development by NASA's Space Technology Mission Directorate to further the knowledge and capabilities necessary to enable future missions to an asteroid, Mars and beyond. Learn more here.

The full text of this story is available online.

Smith, an ASRC Federal/Analytical Services employee, supports Marshall's Office of Strategic Analysis & Communications.

http://www.nasa.gov/mission_pages/tdm/main

Ball Leads Green Propellant Technology Discussion

NASA's Green Propellant Infusion Mission seeks to demonstrate the capabilities of a new, non-toxic, "green" fuel on orbit in 2016. Following the mission's flight, what is the next step for the hydroxyl ammonium nitrate fuel known as AF-M315E? Ball Aerospace, which leads the project for NASA's Technology Demonstration Missions program, is already looking into the answer to that question.

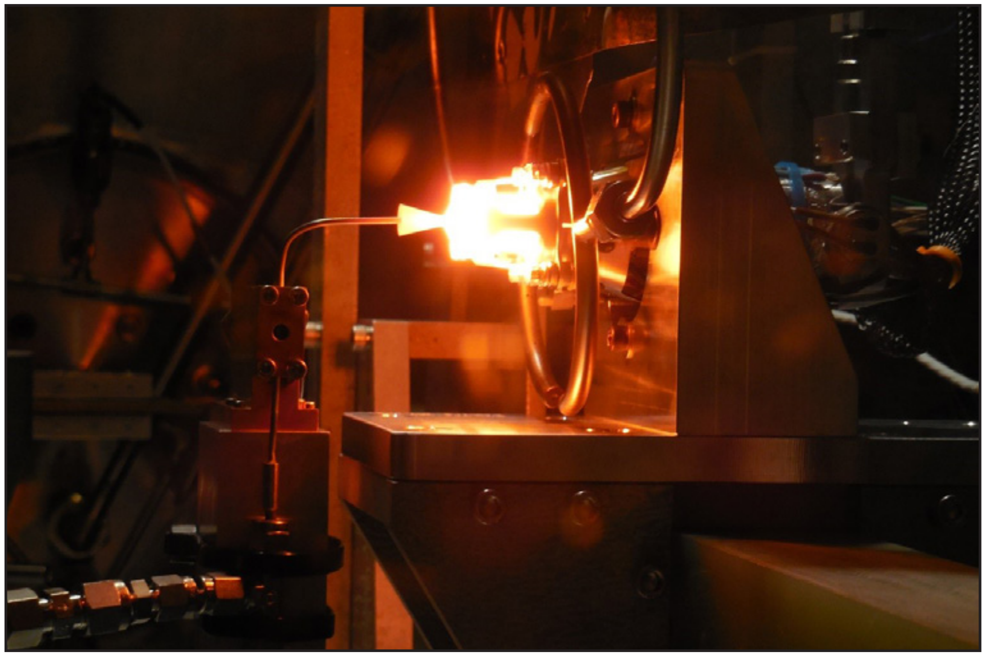
"We want to stay at the forefront of this technology's maturation," said Bryce Unruh, Ball's manager for exploration and technology business development. "Our goal is to be an industry leader for implementing green technologies that meet our customers' mission needs."

Advancements of in-space, storable green propellant technologies have the potential to replace heritage hydrazine and hypergolic systems. The value of these technologies is twofold:

- intrinsic safety associated with the handling of green propellant due to comparatively lower toxicity and reduced explosive ratings; and
- significant increases in performance compared to heritage storable systems.

NASA's Marshall Space Flight Center has been working on a technology maturation roadmap for green propellant technology, Unruh said, and recognized the need to include perspectives from a spacecraft systems integrator. Ball's unique position as the prime contractor on the GPIM project, the first U.S. effort to push a green propellant through the range safety process, gives the company the chance to provide valuable insights to the direction of the roadmap.

Ball was notified by Marshall in March that it had been selected for a 2015 Cooperative Agreement Notice. This project teams experts at Ball and Marshall to identify the best roadmap for the green propellant technology. In coming months, the team will identify what is needed to infuse the green propellant technology into the general spacecraft use community, and will recommend strategic technology investments required to meet this goal.



The GPIM project team completes the fourth hot-fire acceptance test on a 1-Newton thruster June 3 at Aeroject Rocketdyne's Redmond, Washington, facility. The project seeks to develop a high-performance, high-efficiency alternative to conventional chemical propulsion systems for next-generation spacecraft. (Ball/Aerojet Rocketdyne)

"We have identified a number of missions that would be enhanced or enabled by green propellant technology," said Chris McLean, GPIM principal investigator and Ball lead for the roadmap project. "The benefits of green propellant are tantalizing and Ball is in a unique position to engage NASA, [the Department of Defense] and industry and guide the infusion path for the technology."

The company intends to participate in the "Green Monopropellant Alternatives to Hydrazine" Technical Interchange Meeting in August 2015, where a draft of the roadmap will be presented and discussed. The meeting will be hosted by the Joint Army-Navy-NASA-Air Force Interagency Propulsion Committee and the National Institute for Rocket Propulsion Systems. The final version of the roadmap will be delivered to NASA in the fall.

This story is adapted with permission from an article which originally appeared in Ball Aerospace's company newsletter in May.

Marshall TDM Team Tackles 5k

The Technology Demonstration Missions Program Office at NASA's Marshall Space Flight Center was well represented in April when Marshall held its annual Safety, Health & Environmental (SHE) Day activities. Taking part in the 5-kilometer run were, from left, Beth Adams Fogle, TDM mission manager for the Solar Electric Propulsion and eCryo projects; Susan Spencer, TDM mission manager for the Laser Communications Relay Demonstration project; Karen Stephens, TDM integration lead; Tammie Pope, TDM administrative assistant; and Susan Turner, TDM chief engineer. (NASA/MSFC)

Bridge Builder: Grace Tan-Wang

As the Low-Density Supersonic Decelerator team counted down to their June 8 launch (see cover story), we had a chance to chat with Grace Tan-Wang, LDSD operations lead at NASA's Jet Propulsion Laboratory, who shuttled back and forth between her JPL office and the U.S. Navy's Pacific Missile Range Facility to ensure proper design, planning and coordination of supersonic flight dynamic test operations across the entire project team.

Beyond her LDSD role, Tan-Wang is a principal systems engineer at JPL, and has worked on numerous, high-profile NASA planetary missions for almost 30 years there. These included the Mars rovers Spirit and Opportunity, which launched in 2003, and Curiosity, which launched to the Red Planet in 2011. She also has supported outer solar system missions including the Galileo mission to Jupiter, which left Earth in 1989 and the Cassini mission to Saturn, which launched in 1997. Her primary role during the development stages of these missions was in concept, design, building and testing of each spacecraft and its operation.

She joined JPL in 1986, right after earning her bachelor's degree in aeronautical/astronautical engineering from the Massachusetts Institute of Technology in Cambridge, where she also captained the women's gymnastics team. Her first NASA job came in the summer of 1985, however, studying the fluid dynamic effects of interactions of multiple vortex rings at NASA's Ames Research Center. She knew right then, Tan-Wang said, that she wanted to work for the nation's space program.

Tan-Wang, second from left, and her family — from left, daughters Kelly and Marisa and husband Jeff — make time for sightseeing at Waimea Canyon in Kauai, Hawaii, following the first, full-scale LDSD flight test in summer 2014. (Images courtesy of Grace Tan-Wang)

What are your responsibilities on this project?

Even though this is a technology test conducted here on Earth to support future Mars missions, we've developed these operations to be similar to true spaceflight operations. The reason for this is because the test is coordinated across multiple teams, including the balloon and test vehicle operations, range and flight operations, sea recovery operations and safety organizations.

Also, the range we used typically is used for missile tests. Launching a 460-foot-by-396-foot helium balloon at full inflation, with a 6,808-pound, fully fueled test vehicle payload that drops and ignites a solid rocket motor over the ocean is a new operation to develop. We conducted integrated tests with our range, balloon, test vehicle and launch pad teams the same way we do for real Mars mission operations — ensuring the teams are rehearsed and ready for any situation we can conceive of, thus enabling the best possible success of execution.

What's most important to you about your regular JPL job?

A key aspect of systems engineering is ensuring all subsystems are integrated and working together, whether it's spacecraft systems or operations. That's crucial. It's about bringing it all together and doing something that hasn't been done before.

I also can't say enough about the people here at JPL. Everyone takes pride in their work, and we work as a team with a common goal. They're not only brilliant and dedicated, but just great people to work with, too!

What do you hope most to accomplish?

Of course, we are most interested in the data collected for the technologies we are testing — data that will pave the way for the future of Mars exploration as we pursue sample return and human exploration missions. Decades from now, I hope to see common use of these technologies on a multitude of entry missions in space, and the extension of these supersonic decelerators to the next realm of capabilities.

What's been most rewarding about this project?

It's been so rewarding to work with the other organizations involved, including NASA's Wallops Flight Facility, the Pacific Missile Range Facility and the Columbia Scientific Balloon Facility (see related story on pg. 2). Successful test operations require these organizations to work together in an integrated way that has not been done before. The culture at each has been diverse, and each has a wealth of experience and expertise to share. We've all learned a lot from each other and have come together to seek a common goal — a successful test.

How do you hope your work will positively impact NASA's TDM goals?

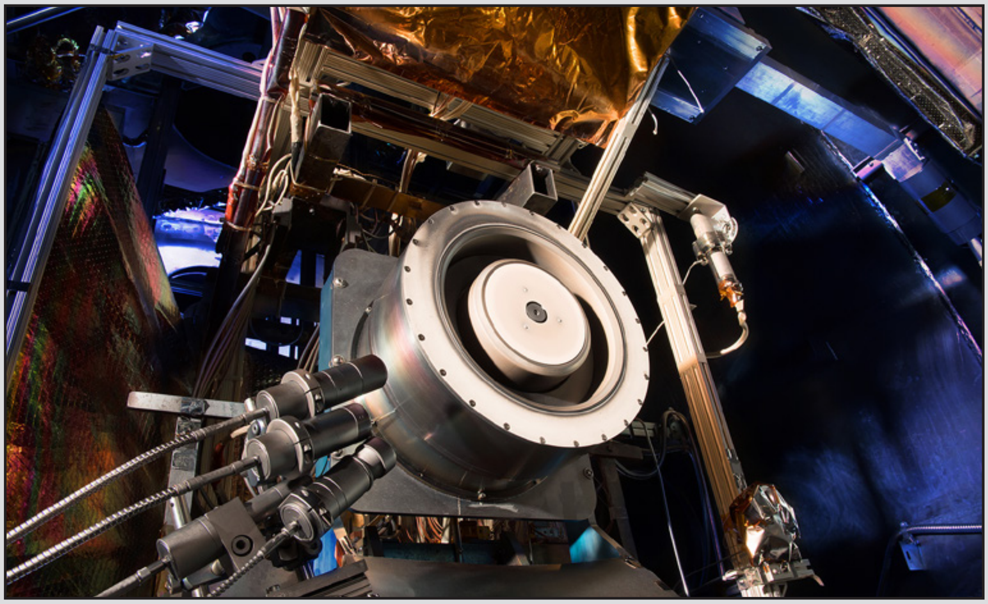
LDSD is a poster project for TDM, and accomplishes its mission statement in a very exciting way. The only way to validate the supersonic technologies needed for future Mars surface missions — without actually testing at Mars — is to put them in a flight-like environment. Not only will the project provide valuable data for supersonic deceleration, but it has created a new wind tunnel venue for large decelerators — LDSD technologies too large for conventional wind tunnels or other test venues.

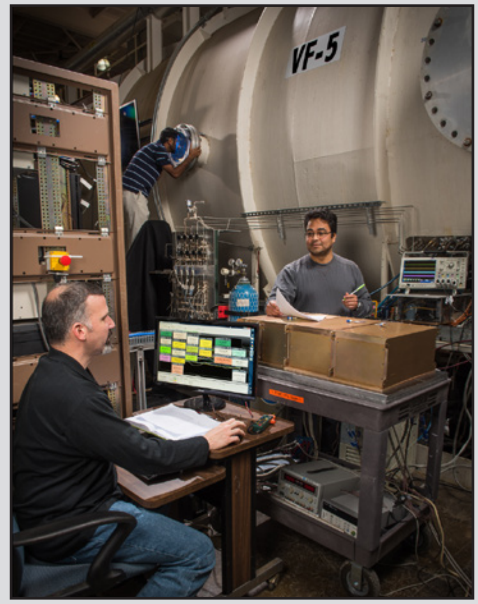
What would most people would be surprised to learn about you?

My parents were born in China, and came to the United States to start a family and give us kids better opportunities. They are both civil engineers. It was groundbreaking for my mother to study civil engineering in Taiwan back then. Also, a fun fact about my family is that my husband and I are both MIT alums — class of 1986 — and both our daughters currently are MIT students as well. Our oldest just graduated in June with a mechanical engineering degree, and our younger daughter is a rising junior working toward a bachelor's degree in mathematics.

Editor's Note: TDM Bridge Builders are team members at various NASA centers and partner organizations who are helping bridge the gap, bringing one of our cutting-edge technologies to flight readiness. Got a suggestion for a team member worthy of a place in the limelight? Email Rick Smith.

Solar Electric Propulsion: Giving the Future a Push





Engineers at NASA's Glenn Research Center recently tested a Hall thruster, above left, part of an innovative Solar Electric Propulsion system that uses 10 times less propellant than conventional chemical rockets. Using a Glenn vacuum chamber to simulate the space environment, team members from the Jet Propulsion Laboratory joined Glenn engineers — including, above right, Glenn engineers Luis Pinero, left; Marcelo Gonzalez, right; and Rohit Shastry — to successfully test a new, higher-powered Hall thruster redesign that offers greater efficiency and longer life. Hall thrusters trap electrons in a magnetic field, ionizing the onboard propellant. The magnetic field also generates an electric field which accelerates the charged ions, creating a plasma exhaust plume that can push a spacecraft forward. The SEP project, one of NASA's newest Technology Demonstration Missions, could propel the first-ever mission to redirect an asteroid in the 2020s, and could ferry large, regular cargo payloads to Mars to support future human missions there. (Images: NASA/GRC)

NASA Day on the Hill: Sharing Our Success Stories

Technology Demonstration Missions projects were a major part of the NASA story in April during annual "NASA Day on the Hill" activities, held this year in the Rayburn House Office Building in Washington. TDM projects showcasing hardware at the event included the Deep Space Atomic Clock project, the Composites for Engineering Upper Stage project, the Green Propellant Infusion Mission project, the Laser Communications Relay Demonstration project and the Solar Electric Propulsion project. TDM personnel on hand to share project information with members of Congress, their staffers and other stakeholders included, clockwise from lower left, Todd Ely, at right, principal investigator for the DSAC project at the Jet Propulsion Laboratory; Amber Jacobson, a project support specialist at NASA's Goddard Space Flight Center; and Steve Moon, at center, a principal engineer at NASA's Marshall Space Flight Center. (Top left and bottom images: MSFC/Steve Moon; top right image: NASA/Joel Kowsky)

Q&A: Meet TDM Program Manager Larry Gagliano...continued from p. 1

Most recently, he worked on the Orion Program, led by NASA's Johnson Space Center, and since 2010 he had been deputy project manager for Orion's Launch Abort System. Then he got the TDM call.

What are your goals and expectations for the TDM Program?

We're firmly in the business of developing robust, cost-effective new technologies to serve NASA's mission in coming years. It's the goal of the Level 2 program office at Marshall to help all our TDM projects around the country achieve success. The Space Technology Mission Directorate at NASA Headquarters, led by STMD Associate Administrator Steve Jurczyk, is responsible for setting strategies and building our business portfolio. They look to us to execute those strategies and ensure the projects reach each milestone and achieve each incremental goal on the path to flight testing and technology infusion.

We've got so many exciting things happening right now. We currently provide program oversight for seven TDM projects: the Deep Space Atomic Clock; eCryo; the Green Propellant Infusion Mission; the Laser Communications Relay Demonstration project; the Low-Density Supersonic Decelerator, which just completed its second flight test in Hawaii; the Solar Electric Propulsion project; and our newest, the Composites for Exploration Upper Stage project [for which a new TDM Web page is under construction; stay tuned! — Ed.].

Our job, working with the project managers and principal investigators at their respective NASA field centers or industry facilities, is to provide overall project assessment. Are they on schedule? Are they doing the things they need to do to reach that next milestone?

What are TDM's strengths? What makes it valuable to programs such as the Space Launch System, the nation's new heavy-lift launch vehicle?

What this program does best is allow NASA's largest flagship programs — SLS, the Orion crew module, the International Space Station — to operate without worrying internally about developing all those secondary or supplementary technologies they'll need down the road. That can be a hindrance to overall progress. At the same time, every large program knows it must evolve, infusing new technologies that will provide better, more cost-effective solutions.

TDM provides a conduit for those new technologies, developing and maturing innovative solutions, reducing risk by ground-testing and flight-testing them before they're plugged into those top-level vehicles and missions. We can go off and do this work and then go to those programs and say, "Here's something we think you can use."

Look at Mars, for example. Right now we're limited in the amount of payload mass we can safely land on the surface. But the new solutions offered by the LDSD project could double or triple the amount of payload we can land there in the future. We pursue that so the teams working on SLS and Orion — the vehicles that will make the journey to Mars possible — can stay focused on the big picture. That's the benefit. When we get these technologies flight-ready, they'll enhance those big programs, open up new doors for them and dramatically improve what we can do on future missions to Mars and other solar system destinations.

What are the primary challenges the program faces?

The big challenge is successfully executing each project. These are very high-risk, high-reward projects — as they should be. Everything we're doing is very new. Many of these things have never been done before. That presents new challenges because we find ourselves inventing as we go. But that's the case with innovation, and whether every project is fully successful or not, we're dramatically enhancing NASA's knowledge and capabilities — and that of our various project partners as well. We make progress even when we run into obstacles or roadblocks.

You mentioned our partners. How valuable is partnership to TDM's success?

Partnership truly is the way of the future. You just have to look at the parties involved in getting the LDSD test vehicle to its June flight test to see that in action!

Everyone struggles with budget limitations these days, and technology research and development can be particularly hard-hit when balanced against the near-term budget needs of large flagship programs. Having multiple stakeholders involved — not just various NASA field centers but military partners, industry, academia and other government agencies — allows us to share funding burdens and deliver more effective technology infusion plans. Plus, partnerships are just good for everyone involved, creating new avenues of collaboration and building a network of talent and expertise we can call on for future programs and missions.

How would you sum up your philosophy of leadership?

One word: empowerment. We have great people here, a unique and talented community. Everybody has a job to do, and the TDM team does theirs very well. Mine is to make sure they've got everything they need — resources, facilities, equipment — to be successful.

I try to keep an eye on the horizon so I'll know what's coming, so I can share information with the team or shield them from distractions, enabling them to stay focused on the work. And I'm their champion. I want them to stay excited and passionate about their work, and most of all, I want them to know what they're doing is important — because it is.

National Aeronautics and Space Administration

George C. Marshall Space Flight Center
Huntsville, AL 35812
www.nasa.gov/marshall

www.nasa.gov

NP-2015-07-57-MSFC
G-109794